



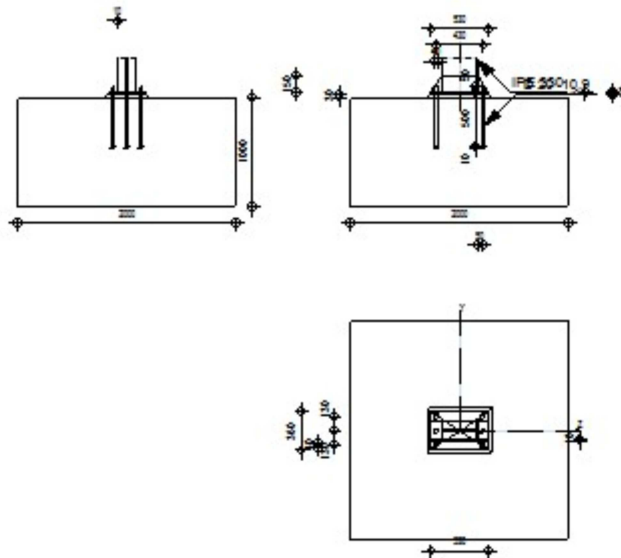
Autodesk Robot Structural Analysis Professional 2015

## Fixed column base design

Eurocode 3: EN 1993-1-8:2005/AC:2009 + CEB Design Guide:  
Design of fastenings in concrete

OK

Ratio  
**0.93**



## GENERAL

Connection no.: 1  
Connection name: Pilar I

## GEOMETRY

### COLUMN

Section: IPE 330  
 $L_c = 15.15$  [m] Column length  
Material: S 235

### COLUMN BASE

$l_{pd} = 530$  [mm] Length  
 $b_{pd} = 360$  [mm] Width  
 $t_{pd} = 20$  [mm] Thickness  
Material: S 235  
 $f_{ypd} = 235.00$  [MPa] Resistance  
 $f_{upd} = 360.00$  [MPa] Yield strength of a material

## **ANCHORAGE**

The shear plane passes through the UNTHREADED portion of the bolt.

Class =	10.9	Anchor class
$f_{yb} =$	900.00 [MPa]	Yield strength of the anchor material
$f_{ub} =$	1000.00 [MPa]	Tensile strength of the anchor material
d =	20 [mm]	Bolt diameter
$n_H =$	2	Number of bolt columns
$n_V =$	3	Number of bolt rows
Horizontal spacing $e_{Hi} =$	430 [mm]	
Vertical spacing $e_{Vi} =$	130 [mm]	

## **STIFFENER**

$l_s =$	530 [mm]	Length
$h_s =$	150 [mm]	Height
$t_s =$	10 [mm]	Thickness

## **MATERIAL FACTORS**

$\gamma_{M0} =$	1.00	Partial safety factor
$\gamma_{M2} =$	1.25	Partial safety factor
$\gamma_C =$	1.50	Partial safety factor

## **SPREAD FOOTING**

L =	2000 [mm]	Spread footing length
B =	2000 [mm]	Spread footing width
H =	1000 [mm]	Spread footing height

### **Concrete**

Class	C25/30	
$f_{ck} =$	25.00 [MPa]	Characteristic resistance for compression

### **Grout layer**

$t_g =$	30 [mm]	Thickness of leveling layer (grout)
$f_{ck,g} =$	12.00 [MPa]	Characteristic resistance for compression
$C_{f,d} =$	0.30	Coeff. of friction between the base plate and concrete

## **WELDS**

$a_p =$	6 [mm]	Footing plate of the column base
$a_s =$	4 [mm]	Stiffeners

## LOADS

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Case: Manual calculations.

$N_{j,Ed}$	=	48.00	[kN]	Axial force
$V_{j,Ed,y}$	=	3.00	[kN]	Shear force
$V_{j,Ed,z}$	=	23.00	[kN]	Shear force
$M_{j,Ed,y}$	=	88.00	[kN*m]	Bending moment
$M_{j,Ed,z}$	=	7.00	[kN*m]	Bending moment

## RESULTS

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### COMPRESSION ZONE

#### COMPRESSION OF CONCRETE

$c$	=	31	[mm]	Additional width of the bearing pressure zone	[6.2.5.(4)]
$f_{jd}$	=	33.33	[MPa]	Design bearing resistance	[6.2.5.(7)]
$F_{c,Rd,y}$	=	922.97	[kN]	Bearing resistance of concrete for bending $M_y$	[6.2.8.3.(1)]
$F_{c,Rd,z}$	=	1270.43	[kN]	Bearing resistance of concrete for bending $M_z$	[6.2.8.3.(1)]

#### COLUMN FLANGE AND WEB IN COMPRESSION

$M_{c,Rd,y}$	=	519.09	[kN*m]	Design resistance of the section for bending	EN1993-1-1:[6.2.5]
$h_{f,y}$	=	370	[mm]	Distance between the centroids of flanges	[6.2.6.7.(1)]
$F_{c,fc,Rd,y}$	=	1404.51	[kN]	Resistance of the compressed flange and web	[6.2.6.7.(1)]
$M_{c,Rd,z}$	=	247.85	[kN*m]	Design resistance of the section for bending	EN1993-1-1:[6.2.5]
$h_{f,z}$	=	170	[mm]	Distance between the centroids of flanges	[6.2.6.7.(1)]
$F_{c,fc,Rd,z}$	=	1457.94	[kN]	Resistance of the compressed flange and web	[6.2.6.7.(1)]

#### RESISTANCES OF SPREAD FOOTING IN THE COMPRESSION ZONE

$F_{C,Rd,y}$	=	$\min(F_{c,Rd,y}, F_{c,fc,Rd,y})$			
$F_{C,Rd,y}$	=	922.97	[kN]	Resistance of spread footing in the compression zone	[6.2.8.3]
$F_{C,Rd,z}$	=	$\min(F_{c,Rd,z}, F_{c,fc,Rd,z})$			
$F_{C,Rd,z}$	=	1270.43	[kN]	Resistance of spread footing in the compression zone	[6.2.8.3]

### TENSION ZONE

#### STEEL FAILURE

$$F_{t,Rd,s1} = 149.94 \quad [\text{kN}] \quad \text{Anchor resistance to steel failure} \quad [\text{Table 3.4}]$$

$$F_{t,Rd,s2} = 183.75 \quad [\text{kN}] \quad \text{Anchor resistance to steel failure} \quad \text{CEB [9.2.2]}$$

$$F_{t,Rd,s} = \min(F_{t,Rd,s1}, F_{t,Rd,s2})$$

$$F_{t,Rd,s} = 149.94 \quad [\text{kN}] \quad \text{Anchor resistance to steel failure}$$

**PULL-OUT FAILURE**

$$F_{t,Rd,p} = 189.74 \quad [\text{kN}] \quad \text{Design uplift capacity} \quad \text{CEB [9.2.3]}$$

**CONCRETE CONE FAILURE**

$$N_{Rk,c}^0 = 419.26 \quad [\text{kN}] \quad \text{Design uplift capacity} \quad \text{CEB [9.2.4]}$$

$$F_{t,Rd,c} = 194.10 \quad [\text{kN}] \quad \text{Design anchor resistance to concrete cone failure} \quad \text{EN 1992-1:[8.4.2.(2)]}$$

**SPLITTING FAILURE**

$$N_{Rk,c}^0 = 419.26 \quad [\text{kN}] \quad \text{Design uplift capacity} \quad \text{CEB [9.2.5]}$$

$$F_{t,Rd,sp} = 194.10 \quad [\text{kN}] \quad \text{Design anchor resistance to splitting of concrete} \quad \text{CEB [9.2.5]}$$

**TENSILE RESISTANCE OF AN ANCHOR**

$$F_{t,Rd} = \min(F_{t,Rd,s}, F_{t,Rd,p}, F_{t,Rd,c}, F_{t,Rd,sp})$$

$$F_{t,Rd} = 149.94 \quad [\text{kN}] \quad \text{Tensile resistance of an anchor}$$

**BENDING OF THE BASE PLATE**

$$F_{t,pl,Rd,y} = 333.46 \quad [\text{kN}] \quad \text{Tension resistance of a plate} \quad [6.2.4]$$

$$F_{t,pl,Rd,z} = 259.48 \quad [\text{kN}] \quad \text{Tension resistance of a plate} \quad [6.2.4]$$

**RESISTANCES OF SPREAD FOOTING IN THE TENSION ZONE**

$$N_{j,Rd} = 666.91 \quad [\text{kN}] \quad \text{Resistance of a spread footing for axial tension} \quad [6.2.8.3]$$

$$F_{T,Rd,y} = F_{t,pl,Rd,y}$$

$$F_{T,Rd,y} = 333.46 \quad [\text{kN}] \quad \text{Resistance of a column base in the tension zone} \quad [6.2.8.3]$$

$$F_{T,Rd,z} = F_{t,pl,Rd,z}$$

$$F_{T,Rd,z} = 259.48 \quad [\text{kN}] \quad \text{Resistance of a column base in the tension zone} \quad [6.2.8.3]$$

**CONNECTION CAPACITY CHECK**

$$N_{j,Ed} / N_{j,Rd} \leq 1,0 \quad (6.24) \quad 0.07 < 1.00 \quad \text{verified} \quad (0.07)$$

$$M_{j,Rd,y} = 121.11 \quad [\text{kN*m}] \quad \text{Connection resistance for bending} \quad [6.2.8.3]$$

$$M_{j,Ed,y} / M_{j,Rd,y} \leq 1,0 \quad (6.23) \quad 0.73 < 1.00 \quad \text{verified} \quad (0.73)$$

$$M_{j,Rd,z} = 35.25 \quad [\text{kN*m}] \quad \text{Connection resistance for bending} \quad [6.2.8.3]$$

$$M_{j,Ed,z} / M_{j,Rd,z} \leq 1,0 \quad (6.23) \quad 0.20 < 1.00 \quad \text{verified} \quad (0.20)$$

$$M_{j,Ed,y} / M_{j,Rd,y} + M_{j,Ed,z} / M_{j,Rd,z} \leq 1,0 \quad 0.93 < 1.00 \quad \text{verified} \quad (0.93)$$

## SHEAR

### BEARING PRESSURE OF AN ANCHOR BOLT ONTO THE BASE PLATE

$$F_{1,vb,Rd,y} = 218.18 \quad [\text{kN}] \quad \text{Resistance of an anchor bolt for bearing pressure onto the base plate} \quad [6.2.2.(7)]$$

$$F_{1,vb,Rd,z} = 218.18 \quad [\text{kN}] \quad \text{Resistance of an anchor bolt for bearing pressure onto the base plate} \quad [6.2.2.(7)]$$

### SHEAR OF AN ANCHOR BOLT

$$F_{2,vb,Rd} = 62.33 \quad [\text{kN}] \quad \text{Shear resistance of a bolt - without lever arm} \quad [6.2.2.(7)]$$

$$F_{v,Rd,sm} = 16.39 \quad [\text{kN}] \quad \text{Shear resistance of a bolt - with lever arm} \quad \text{CEB [9.3.1]}$$

### CONCRETE PRY-OUT FAILURE

$$F_{v,Rd,cp} = 388.21 \quad [\text{kN}] \quad \text{Concrete resistance for pry-out failure} \quad \text{CEB [9.3.1]}$$

### CONCRETE EDGE FAILURE

$$F_{v,Rd,c,y} = 425.94 \quad [\text{kN}] \quad \text{Concrete resistance for edge failure} \quad \text{CEB [9.3.1]}$$

$$F_{v,Rd,c,z} = 502.69 \quad [\text{kN}] \quad \text{Concrete resistance for edge failure} \quad \text{CEB [9.3.1]}$$

### SPLITTING RESISTANCE

$$F_{f,Rd} = 0.00 \quad [\text{kN}] \quad \text{Slip resistance} \quad [6.2.2.(6)]$$

### SHEAR CHECK

$$V_{j,Rd,y} = n_b \cdot \min(F_{1,vb,Rd,y}, F_{2,vb,Rd}, F_{v,Rd,sm}, F_{v,Rd,cp}, F_{v,Rd,c,y}) + F_{f,Rd}$$

$$V_{j,Rd,y} = 98.34 \quad [\text{kN}] \quad \text{Connection resistance for shear} \quad \text{CEB [9.3.1]}$$

$$V_{j,Ed,y} / V_{j,Rd,y} \leq 1,0 \quad 0.03 < 1.00 \quad \text{verified} \quad (0.03)$$

$$V_{j,Rd,z} = n_b \cdot \min(F_{1,vb,Rd,z}, F_{2,vb,Rd}, F_{v,Rd,sm}, F_{v,Rd,cp}, F_{v,Rd,c,z}) + F_{f,Rd}$$

$$V_{j,Rd,z} = 98.34 \quad [\text{kN}] \quad \text{Connection resistance for shear} \quad \text{CEB [9.3.1]}$$

$$V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0 \quad 0.23 < 1.00 \quad \text{verified} \quad (0.23)$$

$$V_{j,Ed,y} / V_{j,Rd,y} + V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0 \quad 0.26 < 1.00 \quad \text{verified} \quad (0.26)$$

## STIFFENER CHECK

**Trapezoid plate parallel to the column web**

$\sigma_d =$	8.53 [MPa]	Normal stress on the contact surface between stiffener and plate	EN 1993-1-1:[6.2.1.(5)]
$\sigma_g =$	82.53 [MPa]	Normal stress in upper fibers	EN 1993-1-1:[6.2.1.(5)]
$\tau =$	86.69 [MPa]	Tangent stress in a stiffener	EN 1993-1-1:[6.2.1.(5)]
$\sigma_z =$	150.39 [MPa]	Equivalent stress on the contact surface between stiffener and plate	EN 1993-1-1:[6.2.1.(5)]
$\max(\sigma_g, \tau / (0.58), \sigma_z) / (f_{yp} / \gamma_{M0}) \leq 1.0$ (6.1)		0.64 < 1.00	verified (0.64)

**WELDS BETWEEN THE COLUMN AND THE BASE PLATE**

$\sigma_{\perp} =$	41.58 [MPa]	Normal stress in a weld	[4.5.3.(7)]
$\tau_{\perp} =$	41.58 [MPa]	Perpendicular tangent stress	[4.5.3.(7)]
$\tau_{yII} =$	0.80 [MPa]	Tangent stress parallel to $V_{j,Ed,y}$	[4.5.3.(7)]
$\tau_{zII} =$	1.89 [MPa]	Tangent stress parallel to $V_{j,Ed,z}$	[4.5.3.(7)]
$\beta_W =$	0.80	Resistance-dependent coefficient	[4.5.3.(7)]
$\sigma_{\perp} / (0.9 * f_u / \gamma_{M2}) \leq 1.0$ (4.1)		0.16 < 1.00	verified (0.16)
$\sqrt{(\sigma_{\perp}^2 + 3.0 (\tau_{yII}^2 + \tau_{zII}^2))} / (f_u / (\beta_W * \gamma_{M2})) \leq 1.0$ (4.1)		0.23 < 1.00	verified (0.23)
$\sqrt{(\sigma_{\perp}^2 + 3.0 (\tau_{zII}^2 + \tau_{\perp}^2))} / (f_u / (\beta_W * \gamma_{M2})) \leq 1.0$ (4.1)		0.18 < 1.00	verified (0.18)

**VERTICAL WELDS OF STIFFENERS**

**Trapezoid plate parallel to the column web**

$\sigma_{\perp} =$	0.00 [MPa]	Normal stress in a weld	[4.5.3.(7)]
$\tau_{\perp} =$	0.00 [MPa]	Perpendicular tangent stress	[4.5.3.(7)]
$\tau_{II} =$	108.36 [MPa]	Parallel tangent stress	[4.5.3.(7)]
$\sigma_z =$	0.00 [MPa]	Total equivalent stress	[4.5.3.(7)]
$\beta_W =$	0.80	Resistance-dependent coefficient	[4.5.3.(7)]
$\max(\sigma_{\perp}, \tau_{II} * \sqrt{3}, \sigma_z) / (f_u / (\beta_W * \gamma_{M2})) \leq 1.0$ (4.1)		0.52 < 1.00	verified (0.52)

**TRANSVERSAL WELDS OF STIFFENERS**

**Trapezoid plate parallel to the column web**

$\sigma_{\perp} =$	114.93 [MPa]	Normal stress in a weld	[4.5.3.(7)]
$\tau_{\perp} =$	114.93 [MPa]	Perpendicular tangent stress	[4.5.3.(7)]
$\tau_{II} =$	139.54 [MPa]	Parallel tangent stress	[4.5.3.(7)]
$\sigma_z =$	333.55 [MPa]	Total equivalent stress	[4.5.3.(7)]
$\beta_W =$	0.80	Resistance-dependent coefficient	[4.5.3.(7)]
$\max(\sigma_{\perp}, \tau_{II} * \sqrt{3}, \sigma_z) / (f_u / (\beta_W * \gamma_{M2})) \leq 1.0$ (4.1)		0.93 < 1.00	verified (0.93)

**CONNECTION STIFFNESS**

Bending moment  $M_{j,Ed,y}$

$k_{13,y} = 15$  [mm] Stiffness coeff. of compressed concrete [Table 6.11]

$k_{15,y} = 5$  [mm] Stiffness coeff. of the base plate subjected to tension [Table 6.11]

$k_{16,y} = 2$  [mm] Stiffness coeff. of an anchor subjected to tension [Table 6.11]

$\lambda_{0,y} = 1.18$  Column slenderness [5.2.2.5.(2)]

$S_{j,ini,y} = 29280.27$  [kN\*m] Initial rotational stiffness [Table 6.12]

$S_{j,rig,y} = 48934.89$  [kN\*m] Stiffness of a rigid connection [5.2.2.5]

$S_{j,ini,y} < S_{j,rig,y}$  SEMI-RIGID [5.2.2.5.(2)]

#### Bending moment $M_{j,Ed,z}$

$k_{13,z} = 23$  [mm] Stiffness coeff. of compressed concrete [Table 6.11]

$k_{15,z} = 14$  [mm] Stiffness coeff. of the base plate subjected to tension [Table 6.11]

$k_{16,z} = 2$  [mm] Stiffness coeff. of an anchor subjected to tension [Table 6.11]

$\lambda_{0,z} = 4.55$  Column slenderness [5.2.2.5.(2)]

$S_{j,ini,z} = 9435.33$  [kN\*m] Initial rotational stiffness [6.3.1.(4)]

$S_{j,rig,z} = 3277.64$  [kN\*m] Stiffness of a rigid connection [5.2.2.5]

$S_{j,ini,z} > S_{j,rig,z}$  RIGID [5.2.2.5.(2)]

#### WEAKEST COMPONENT:

STIFFENER - HORIZONTAL WELDS

**Connection conforms to the code**

Ratio 0.93